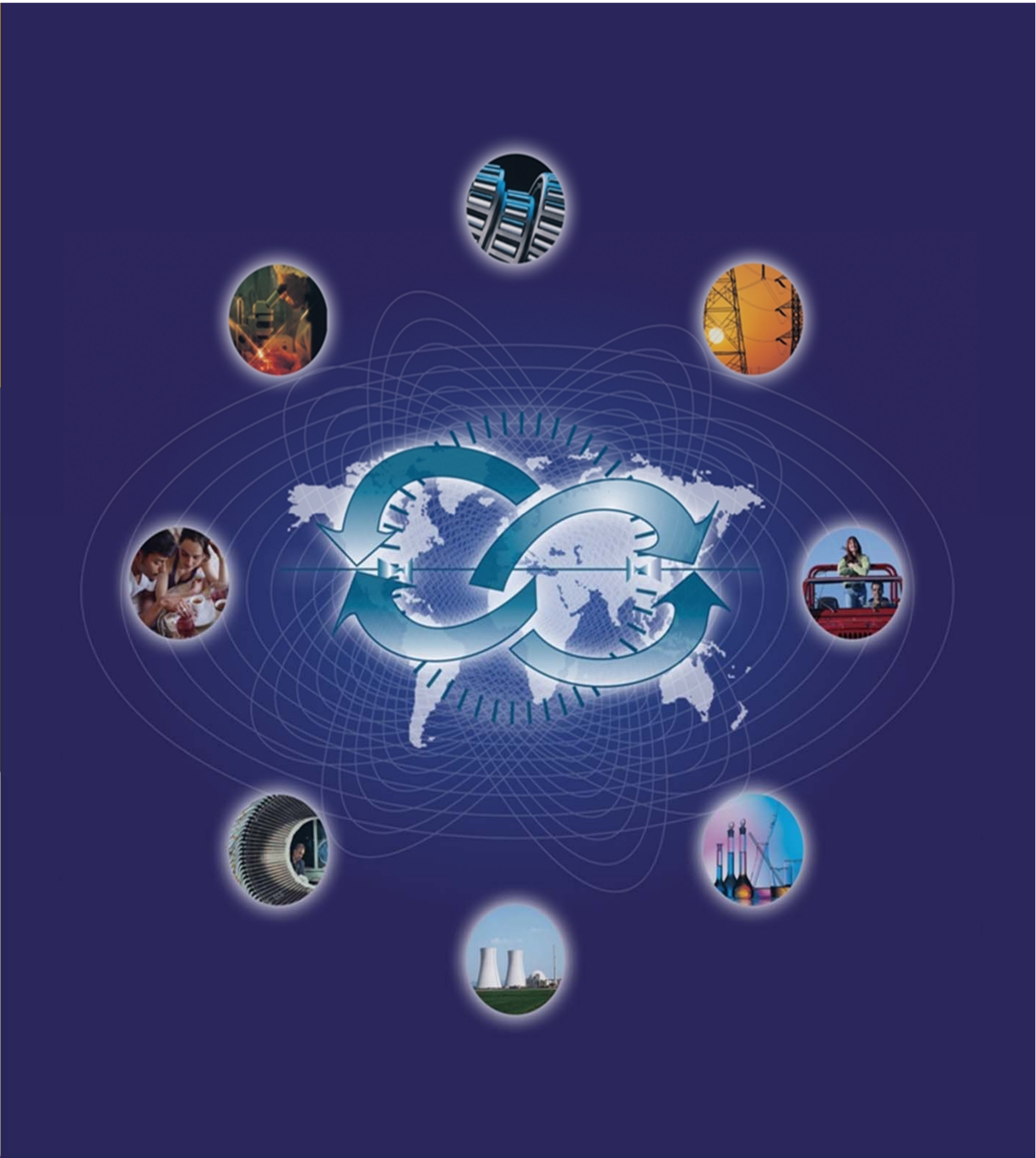

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The Future(s) of the Energy Consumption of Private Households in Germany – A Multilevel Cross-Impact Analysis

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The Future(s) of the Energy Consumption of Private Households in Germany – A Multilevel Cross-Impact Analysis

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Executive Summary

A major goal concerning the energy transition in Germany is the reduction of energy usage. In 2011, private households consumed 2.194 PJ and thus have been identified as a sector with high energy reduction potential. The energy demand of this sector is dependent on many different linked quantitative and qualitative factors (e.g. number of persons and demographic structure, disposable income, expenditure, and the cost of energy-saving measures). In our study we introduce a multilevel cross-impact approach which allows for the defining and quantifying of the data for scenario analysis while taking the interdependences between different factors on global, national and sectoral level into account. This approach makes it possible to overcome limitations conventional energy models are usually confronted with. By applying a trend analysis in combination with information on relevant factors on a global and national level, consistent sectoral views of of the private household's future is created.The developments for the trend scenario correlate with the average growth of energy prices, stagnating incomes, a slowed expansion of renewable energy as well as the network infrastructure. The final energy consumption for indoor and water heating can be reduced by 12% if measures are held in place until 2030. In 2030, this will be materialised in a greenhouse gas emission reduction of 30 million tonnes to approximately 74 million tonnes of CO_2 equivalent and by around 44% relative to the base level of 1990. In order to achieve long term climate goals, an international climate agreement in combination with a high level of commitment from government and stakeholders has been put in place. The aim is to reduce energy consumption so that the influencing factors function as default for the transformation scenario. Compared to the trend scenario, emission levels can be lowered from 38 million to 36 million tonnes of CO_2 equivalent by implementing the transformation scenario.

Keywords

Cross-Impact Analysis, Energy consumption of private households

Contribution to

Energy-Trans

I Introduction

In order to limit the effects of global warming to 2°C, the EU has committed to reducing 20% of greenhouse gas emissions by 2020 compared to 1990 levels. By 2050 developed countries should reduce their greenhouse gas emissions by 80 to 95% in comparison to 1990 levels [EU-Rat, 2009a]. The German government has confirmed the climate change targets till 2050 in the German energy concept [BMWi, 2010]. Due to the decision to accelerate the phasing out of nuclear energy, the contribution of climate change and energy efficiency in buildings is becoming increasingly important [BMWi, 2011]. A major goal of the German energy transition is the reduction of energy consumption. Approximately 28.5% of the final energy consumption stems from the household sector, making the households crucial for energy reduction strategies. Indeed, the residential sector holds great potential for the reduction of energy use. Old buildings form the focus of this study, as more than 70% of current residential buildings were constructed before 1977 when the first insulation regulations were put in place. Renovations must occur to achieve carbon-neutral buildings as well as extensive time plans that include financing in order to double the modernization rate to 2% per year. In this study, strategies to reduce the energy demand of households are investigated in scenarios that take into consideration the updates of current climate change policies as well as addition measures that can be put in place to achieve climate change goals.

A multilevel cross-impact method is applied to analyse trends and interdependencies of various quantitative and qualitative factors on global, national and sectoral level. Specific energy savings and CO_2 reductions in the German residential sector are shown per scenario till 2030 by means of a building simulation model.

II Methodology

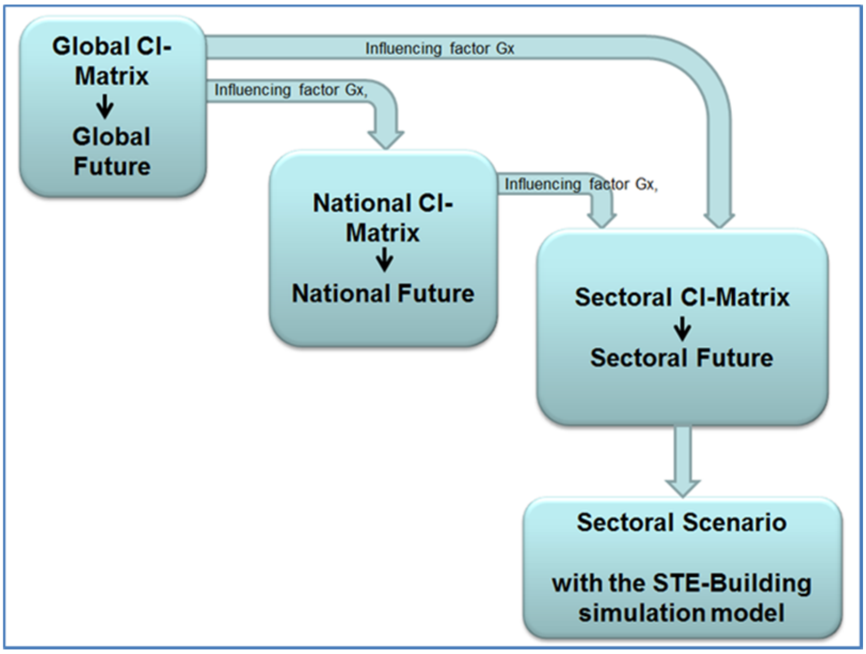
For the creation of scenarios, the effects of different influencing factors are examined. In order to develop model-based scenarios, it is necessary to make assumptions regarding the social, political, economic and technological development framework. The data frame developments for energy models are chosen in coordination with exogenously decided upon scenarios. This is in order to make statements for the future course of energy consumption and greenhouse gas emissions in the household sector. To reduce energy demand of households, strategies are formulated as it is necessary to determine plausible scenarios and a consistent data frame for influencing factors.

An instrument to qualitatively assess the main drivers and their interactions for the design of future views is the cross-impact analysis [Weimer-Jehle 2012]. In order to track the impact of global trends and national influences on energy demand in the residential sector, [Weimer-Jehle 2012]'s scheme is employed. Based on these trends, relevant influencing factors for future energy demand on global, national and sectoral levels are revealed by connecting the trends to the scenario data frames.

The cross-impact method is carried out in several steps. First, an expert survey is conducted in order to record influencing factors and their possible values. Then, experts opinions are used identify interactions between factors as well as direct correlations. The Weimer-Jehle, (2012) model is used to evaluate direct influences. In this model, integers from -3 (strongly disagree) to +3 (strongly agree) are used. By piecing together the gathered data, the cross-impact matrix is created displaying consistent trends (see [Weimer-Jehle, 2006, Weimer-Jehle, 2012, Vögele, 2012]). In order to take into account the overall influencing factors, a multilevel approach is applied. By using an overall cross-matrix, global relationships can quickly be identified. Indeed, a national cross-impact matrix is used to formulate relationships at the national level. Then, a sectoral cross-impact matrix is employed in order to discover specified relationships in the corresponding sector. With the cross-impact method global, national and sectoral scenarios can be created. By using coordinated influencing variables on different levels, resulting scenarios can be merged into pictures of the future. The pictures are mainly qualitative for future development possibilities.

The coupling of the different levels is used for the specification of the scenario analysis and building simulation model (Fig. 1).

Fig. 1: Methodological approach for the multi-stage analysis



Source: IEK-STE IEK-STE 2013

The advantage of the multilevel approach is that all plausible development possibilities are not only identified, but also clearly presented. These development opportunities serve as guidelines in order to determine scenarios as well as the framework and guiding parameters for the building simulation model. This model is a dynamic simulation model that simulates the energy demand for residential buildings in a timely manner. The model also maps technical options in the form of scenarios. Due to a comprehensive database of age, size, heating and hot water systems classes of the residential sector, the entire sector can be viewed and updated dynamically (see [Krause et al., 2011]).

II.1 Future images on the global level

The selected influencing factors and their possible outcomes for the global level are listed in the table below.

Tab. 1: Influencing factors on the global level

Field	Influencing factor	Possible outcome
Innovation dynamics	Innovation dynamics	- Large innovations - Average changes
Technology-specific factors	Global energy efficiency	- Constant - Accelerated
Demographic changes	Population development	- Increasing sharply - Increasing - Stagnating
Institutional / political Framework	International climate policy	- Ambitious and coordinated - Matched but less ambitious - No further promotion
Development of resource availability	Resource scarcity	- Increasing - Strongly increasing

Source: IEK-STE 2012 IEK-STE 2013

Three global futures are found through the CI analysis which is conducted with the influencing factor's characteristics. For the ***global future I***, the main assumption is that climate targets are internationally coordinated in order to reduce the expected climate changes. Due to the increasingly growing shortage of resources accompanied by sharply rising commodity prices, it is necessary for global efforts to increase energy efficiency by using large-scale dynamic innovations as well as creating an environment in which businesses are willing to take high risks. Basically, the main assumption is that a further increase in global GDP persists.

In ***global future II***, the reduction of global CO_2 emissions is important, however it is assumed that the international agreement on climate targets is slightly more ambitious. In this scenario, increasing resource scarcity and rise in commodity prices cause slight improvements in energy efficiency as well as innovation dynamics. In this global future, a general assumption is the further increase in global GDP.

Another scenario is ***global future III***. In this future vision, it is assumed that the current international climate targets will not be forced. It is assumed that there will be no new international agreement on climate targets. Moreover, it is assumed that no further reinforcement is offered by global initiatives to increase energy efficiency. The increasing scarcity of resources does not change the risk appetite of firms and consequently, only small changes in innovations are present. Central to this scenario is the promotion of a strong global increase in GDP.

In summary, a variety a factors can influence the future energy demand and supply. In addition to influencing factors stemming from the economy and society, other factors play a large role. Indeed, resource availability and climate change conditions are influencing factors that largely affect these global futures.

II.2 Future images on the national level

The selection of influencing factors and their possible outcomes (see Tab. 2) consist of expert knowledge and various literature sources (e.g., [Matthes et al., 2009 Weimer-Jehle et al., 2011]). These factors and corresponding values have been specifically selected in order to estimate the potential energy economic situation in 2030 for Germany.

Tab. 2: Influencing factors on the national level

Field	Influencing factor	Possible outcomes
Macroeconomic development	GDP	- Minor increase (approx. 0.5% / year) - Strong increase (approx. 1% / year)
Macroeconomic development	Risk-taking (firms)	- Low - High
Price development	Oil price	- High (2030: ~175$/bbl) - Medium (2030:~125$/bbl)
Changes in technology mix	Changes in Energy Efficiency	- Slightly increasing - Strongly increasing
Technology specific factors	Innovation dynamics	- Constant (1% / year) - Increasing (2% / year)
Development of knowledge base	Knowledge generation	- Slightly increasing - Strongly increasing
Demographic change	Population Space requirements Equipment with electric devices (Private Households)	- Slight decrease (2030: 79 million) - Strong decrease (2030: 77 million) - Slight increase (46 m^2 / person) - Strong increasing (50 m^2 / person) - Increasing - Strong increase
Institutional / political framework	Environmental awareness Climate and energy policy	- Unchanged - Increasing - Focus on energy security - Focus on economics - Focus on reducing greenhouse gasses
Development of resource availability	Resource scarcity	- Increasing - Strongly increasing
Climate change	Climate change	- Slightly visible - Clearly visible (Warmer winters, heat waves in the summer)
Energy consumption	Private households Industry Business, trade, services Traffic	- Gradual decline (-1% / year) - Strong decline (-1,5% / year) - Slight increase (0,5% / year) - Gradual decline (-0,5% / year) - Strong decline (-1% / year) - Gradual decline (-1% / year) - Strong decline (-1,5% / year) - Gradual decline (-0,5% / year) - Strong decline (-1% / year)
Energy infrastructure	Expansion of electricity transmission and distribution network	- Restrained - Unrestrained (as proposed by DENA II study)
Technological development	Degree of centralisation Unit size	- Low (relatively even distribution of electricity in Germany) - High (power generation hot-spots) - Increased application of small units - Dominant application of large units
Other	Regional level of diversification	- Constant (situation as it is today) - Increased (increase in the differences between regions)

Source: IEK-STE IEK-STE 2013

Fifty consistent scenarios on a national level can be identified by using the cross-impact approach.

Taking into consideration that certain conditions exist due to the aforementioned trends, a different importance for the development of the energy system can be reduced to a few possible outcomes: In ***national future I and II*** it is assumed that measures are taken in Germany as well as on a global level in order to slow climate changes. It is also assumed that current energy and climate policy objectives are given priority over other goals (e.g. economic and political goals) in Germany. Furthermore, it is assumed that the transmission network can be extended without major limitations. In addition, a slight rise in oil prices is assumed.

However, the national futures I and II differ in the assumed possibility of upgrading the transmission networks. Due to the limitations assumed, the ***national future I*** focuses on the importance of decentralised energy supply. Simultaneously, an increased number of small installations are built. The overall economic development is somewhat slower in this scenario. This affects the migration that in turn influences the country's demography. Therefore, it is assumed that the average population increase will decline. Due to the relatively low GDP and population growth, it is expected that energy demand in end-use sectors will decline.

The ***national future II*** also focuses on the reduction of CO_2 emissions. In contrast to national future I, the oil price is approximately 175$/barrel in this scenario. The high energy prices incentivise end-users to consume less energy. Consequently, the state needs not to intervene as much in order to meet energy and environmental goals. Due to the high oil prices, the cost of transportation rises that in turn limits international trade. Basically, it is assumed that an increase in energy prices slightly slows the overall economic growth in Germany. Finally, the limited expansion of the transmission network causes an increase importance in decentralised power generation systems.

Another set of national futures is ***national future III and IV***. A current example is the discussion of the limitation of the EEG cost apportionment. Past experiences display that energy and environmental policy cannot be achieved with certainty. In this set it is assumed that the current energy and environmental policy goals are not binding and thus can be terminated. It is assumed that by limiting the EEG levy the additional construction of renewable energy delayed. It is also assumed that there will be delays in connecting the grid to offshore wind farms, as well as generally in the domain of network expansion. The climate and energy policy is based on the focus of the economy and an average increase in oil prices. This development is connected with high GDP growth, a slight decline in population numbers and a rapidly increasing demand for space. Environmental awareness is less pronounced here. Moreover, their differences lie in a smaller decline in energy consumption in end-use sectors.

In addition, an average oil price is the basis for the ***national future III***. Changes are only found in the possibility of expanding the existing transmission system. This causes the use of decentralised power facilities to increase. As a result, the perceived limitations lead to the use of smaller decentralised energy supply units.

In national future IV it is also assumed that the current environmental objectives are not necessarily binding. In contrast to the previously described set of futures, it is assumed that global macroeconomic growth rates remain high, resulting in an increasing in resource scarcity. In addition to fossil fuels, rare earth elements are affected. Therefore, it is expected that energy and raw material prices rise significantly. The high energy prices have a slightly discouraging effect on the overall economic development in Germany. However, the GDP will continue to increase relatively strongly. High energy prices provide the incentive to search for alternative energy saving mechanisms and schemes. Also, a strong decline in energy consumption will be found in the transportation sector.

II.3 Future images on the sectoral level

In order to develop consistent sectoral future images, trend analysis and the associated influencing factors at global and national level, the energy demand in the sector private households is determined. Overall, the results take into account the coupling of the different levels of analysis, sets of influencing factors for the energy supply and demand. For the future energy demand and the supply in the household sector in Germany, the influencing factors are displayed in Table 3 for global and national levels. These influencing factors aid the derivation of future images until the year 2030. Based on the sectoral level influencing factors, variants for each influencing factor are established. Of the possible combinations at the sectoral level, a total of four consistent future images for the development up to 2030 are vested (see Table 1 in the Appendix).

Tab. 3: Coupling of influencing factors on different levels

Global Level	National level	Sector "Private Households"
Growth of GDP (world)	Growth of GDP (national level)	Growth of GDP (national level)
Fuel prices	Fuel prices	Fuel prices
Climate policy on global level	Climate/energy policy on national level	Climate/energy policy on sectoral level
Changes in energy efficiency	Changes in energy efficiency	Changes in energy efficiency
Demographic change (world)	Demographic change (national Level)	Demographic change (national Level)
Innovation dynamics	Innovation dynamics	Innovation dynamics
Resource scarcity	Resource scarcity	
Willingness to invest	Willingness to invest	
	Degree of centralisation (energy supply)	Use of decentralised energy supply options in households
	Unit size (energy production units)	
	Expansion of electricity transmission and distribution network	Expansion of electricity transmission and distribution network
	Regional level of diversification	Regional level of diversification

Source: IEK-STE

In the ***sectoral future I***, a correlation is found in the results between the sectoral level and the national as well as global futures II. Also, it is presumed that the climate policy remains globally ambitious as well as internationally coordinated beyond 2020. Additionally, the coupling of the global and national levels strongly increase resource scarcity as well as accelerate risks for the necessary investments to transform the energy system. This causes the national and sectoral levels to strongly influence energy and climate policy as well as the implementation of specific building climate policy instruments in Germany. Here, the raw material price is approximately 175$ / barrel in 2030. The resulting energy prices create an incentive for energy saving. As a consequence, less state intervention is necessary. Basically, it is assumed that an increase in energy prices only slightly slows the overall rate of economic growth in Germany. At all levels, efforts to improve energy efficiency will be achieved. These improvements create a large spurt in innovations that focus on the replacement of old techniques. Due to the assumed limitations of the transmission network expansion, decentralised power generation systems gain an important place in the structure. Consequently, the regional distribution of households becomes increasingly more important. Following this logic, the developments lead to an increased importance of the buildings quality (regarding energy efficiency), which in turn can be related to higher rents and price bids. Overall, this causes the disposable income to decline.

Sectoral futures II and III are very similar to future I. In contrast to future I in these scenarios only the disposable income and the household trends with elderly population vary. Therefore Future II and III can be seen as variations of future I.

An analysis of the ***sectoral future IV*** is displayed in to Table 4. In Table 4, a correlation between the sectoral level and the global as well as national future image I can be observed. At the global and national level, increasing resource scarcity and risk willingness for investments is taken into consideration. The rise in commodity prices is considered to moderately grow. On all levels, the overall economic development only slightly increases. The international climate policy is assumed to be less ambitious and have coordinated approach towards sectoral future I. The national energy and climate policy as well as the climate policy instruments put in place, will have a medium impact on the future energy supply. The energy efficiency and energy quality of buildings is becoming slightly more important. Additionally in the national future I, the expansion of the transmission network is assumed to be slow in Germany. Although the decentralised energy supply is growing, the necessary expansion of the energy infrastructure is slower than in the sectoral future I. Consequently, the regional distribution as well as the trend towards households with elderly population stagnates in significance. Overall, the future developments lead to stagnating rents and purchase prices as well as constant disposable incomes.

Tab. 4: Derivation of scenarios by coupling the sectoral, national and global futures

Future I - "Trend"			Future II - "Transformation"		
Global Future I	**National Future I**	**Sectoral Future IV**	**Global Future II**	**National Future II**	**Sectoral Future I**
Growth of GDP (world)	**Growth of GDP (national level)**	**Growth of GDP (national level)**	**Growth of GDP (national level)**	**Growth of GDP (national level)**	**Growth of GDP (national level)**
Strong increase	Strong increase	Strong increase	Strong increase	Strong increase	Strong increase
Minor increase	Minor increase	Minor increase	Minor increase	Minor increase	Minor increase
Fuel prices	**Fuel prices**	**Fuel prices**	**Fuel prices**	**Fuel prices**	**Fuel prices**
Strong increase	Strong increase	Strong increase	Strong increase	Strong increase	Strong increase
Minor increase	Minor increase	Minor increase	Minor increase	Minor increase	Minor increase
Climate policy on global level	**Climate/energy policy on national level**	**Climate/energy policy on national level**	**Climate policy on global level**	**Climate/energy policy on national level**	**Climate/energy policy on national level**
Ambitious and coordinated	Focus on reducing greenhouse gasses	Focus on reducing greenhouse gasses	Ambitious and coordinated	Focus on reducing greenhouse gasses	Focus on reducing greenhouse gasses
Coordinated but less ambitious	Focus on economics (less ambitious)	Focus on economics (less ambitious)	Coordinated but less ambitious	Focus on economics (less ambitious)	Focus on economics (less ambitious)
Not ambitious			Not ambitious		
Changes in energy efficiency	**Changes in energy efficiency**	**Changes in energy efficiency**	**Changes in energy efficiency**	**Changes in energy efficiency**	**Changes in energy efficiency**
Strongly increasing	Strongly increasing	Strongly increasing	Strongly increasing	Strongly increasing	Strongly increasing
Slightly increasing	Slightly increasing	Slightly increasing	Slightly increasing	Slightly increasing	Slightly increasing
Constant		Constant	Constant		Constant
Demographic change (world)	**Demographic change (national Level)**	**Demographic change (national Level)**	**Demographic change (world)**	**Demographic change (national Level)**	**Demographic change (national Level)**
Strongly increasing	Slight decrease	Slight decrease	Strongly increasing	Slight decrease	Slight decrease
Moderate Increase	Strong decrease	Strong decrease	Moderate Increase	Strong decrease	Strong decrease
Slight increase			Slight increase		
Innovation dynamics	**Innovation dynamics**	**Innovation dynamics**	**Innovation dynamics**	**Innovation dynamics**	**Innovation dynamics**
Increasing	Increasing	Increasing	Increasing	Increasing	Increasing
Constant	Constant	Constant	Constant	Constant	Constant
Resource scarcity	**Resource scarcity**		**Resource scarcity**	**Resource scarcity**	
Increasing	Increasing		Increasing	Increasing	
Strongly increasing	Strongly increasing		Strongly increasing	Strongly increasing	
Willingness to invest	**Willingness to invest**		**Willingness to invest**	**Willingness to invest**	
Constant	Constant		Constant	Constant	
Increasing	Increasing		Increasing	Increasing	
	Unit size (energy production units)	**Unit size (energy production units)**		**Unit size (energy production units)**	**Unit size (energy production units)**
	Increased application of small units	Increased application of small units		Increased application of small units	Increased application of small units
	Dominant application of large units	Dominant application of large units		Dominant application of large units	Dominant application of large units
	Expansion of electricity trans./distrib. network	**Use of dez. energy supply options (HH)**		**Expansion of electricity trans./distrib. network**	**Use of dez. energy supply options (HH)**
	Unrestrained			Unrestrained	
	Restrained	Increasing		Restrained	Increasing
		Strongly increasing			Strongly increasing
	Regional level of diversification	**Regional level of diversification**		**Regional level of diversification**	**Regional level of diversification**
	Increasing	Increasing		Increasing	Increasing
	Constant	Constant		Constant	Constant
		Decreasing			Decreasing
		Disposable income			**Disposable income**
		Increasing			Increasing
		Constant			Constant
		Decreasing			Decreasing
		Working Population (No. of Persons)			**Working Population (No. of Persons)**
		Increasing			Increasing
		Constant			Constant
		Decreasing			Decreasing
		Relevance of households with elderly persons			**Relevance of households with elderly persons**
		Increasing			Increasing
		Constant			Constant
		Decreasing			Decreasing
		Energetic quality of buildings			**Energetic quality of buildings**
		High			High
		Medium			Medium
		Low			Low
		Rental charge/price of building and flats			**Rental charge/price of building and flats**
		Increasing			Increasing
		Constant			Constant
		Decreasing			Decreasing

Source: IEK-STE 2013 IEK-STE 2013

III Scenario analysis in the household sector

The determined, consistent and coupled future pictures displayed in Table 4 are used as an input for the scenario analysis' data frame. According to the analysis described above, the future images can be used as a methodological basis for the qualitative determination of the factors that influence energy demand and supply scenarios for the household sector, taking into account the factors influencing global and national levels.

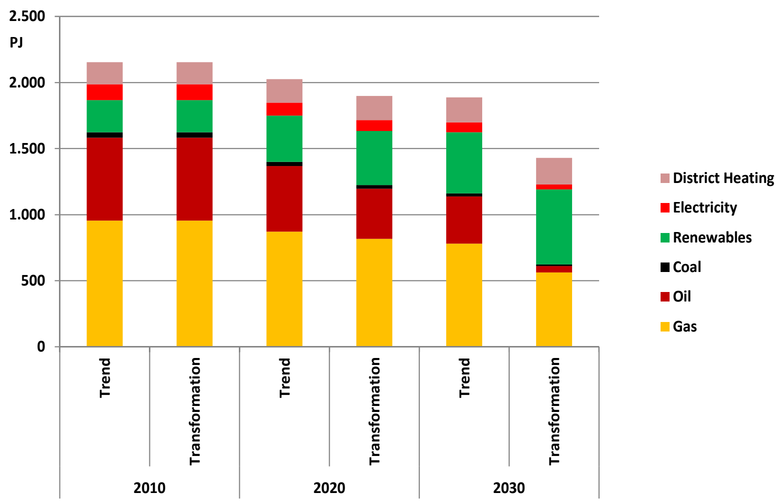
For the scenario calculations, the STE-building simulation model is used. Not only can specified measures for individual buildings be determined in a chronological order, but its effects over a specified observation period can be revealed as well [Hansen et al., 2013]. The model identifies the energy consumption, CO_2 emissions and the costs for space heating and hot water production. The effects of various measures of thermal insulation in the building shell as well as heating system improvements can be estimated with the model. Additionally, all system parameters can vary so that in the main effects of all possible measures can also be calculated in their own combination.

For households, the measures and instruments are included in the trend scenario, which has been decided in the context of the energy concept of the German government in June 2011. This concerns on the one hand, the regulatory instruments such as the Energy Saving Ordinance and the Renewable Energies Heat Act as well as the requirements of the recast European EPBD and other funding instruments such as KfW programs, promotion of urban development, the market incentive program for renewable energy and other measures and campaigns. The funding amount is updated at the level of the current year. The renovation rate of recent years will be extended until 2030. The realisation of the transformation scenario requires further measures and instruments, which are listed in Table 2 of the appendices.

Results of the Projections

The development of final energy demand for space heating and hot water will drop below 1990 levels by 2030 in the trend scenario of 8% to 1,887 PJ whereas in the transformation scenario of 30% final demand will sink to 1,430 PJ (see Table 5).

Tab. 5: Development of final energy consumption for space heating and hot water



Source: IEK-STE 2013 IEK-STE 2013

Measures analysed have a reduced outcome in the trend scenario. Emissions in 2030 are around 33.5 million tonnes CO_2 eq. to 74 million tonnes. This is equivalent to the total emission saving of a reduction rate of 44% in comparison to 1990 levels. The impact assessments of CO_2 reduction effects of the various activities in the trend scenario show that the contribution from the monetary incentives the KfW program for energy efficient renovations of 15 million tonnes and the market incentive program for renewable energies with a total of around 13 million tonnes of CO_2 form the largest contribution. The regulatory actions of the amendment of the regulations and the introduction of the Renewable

Energies Heat Act (EEWärmeG) combined, lead to emission savings of 5 million tonnes of CO_2 (see Table 3 in the Appendices).

The instruments examined in the transformation scenario reduce emissions to more than 37 million tonnes of CO_2-eq. to a total of 36 million tonnes of CO_2-eq compared to the trend scenario for 2030. Compared to 1990 levels, the application of the transformation scenario displays a total emissions reduction of about 72% by 2030. The largest individual contributions strengthen the implementation of the Energy Saving Ordinance of 16.3 million tonnes and the Tax Deductibility of 6.3 million tonnes of CO_2. Due to the simplified renovations in the rental market and the strong market incentive program for renewable energy, an estimated additional 6.2 and 4.9 million tonnes of CO_2 can be saved. (See Tab. 4 in the appendices).

IV Conclusion

The chosen approach is a modular development opportunities for the sector level, taking into account qualitative and quantitative factors on global, national and sectoral level. This allows for the determinants of demand in the household sector to have two major development opportunities for consistent scenario calculations till 2030. In both scenarios created for Germany, a growth rate of 1% per year with a reduction of the population to 78 million is assumed. According to the trend scenario, the continuation of the current climate policy instruments correlate with an average growth of energy prices as well as stagnating incomes and a decelerated expansion of renewable energies and transmission network infrastructure. The governmental subsidies and the energy restructuring activities remain at the current level, so that the energy consumption for space heating and hot water is reduced to 270 PJ by 2030 and 12% compared to 2010 levels. Therefore, greenhouse gas emissions are expected to decrease to about 74 million tonnes CO_2 eq. by 2030. This corresponds to a total emission savings rate of approximately 44% compared to 1990.

It is assumed that the the long-term climate targets can be achieved should international climate agreements be coupled with a high level of state and agent commitment. Together, energy consumption can be reduced by means of using the influencing factors as set guidelines for an economy in the transition scenario. In this scenario, the strong expansion of decentralised energy supply and renewable energy consists of a high drive for innovation and the increasing importance of energy quality of buildings. This transformation of the energy supply reduces the fossil fuel consumption to 1,100 PJ by 2030 and energy consumption to 730 PJ or 34%. The instruments examined reduce emissions to a total of approximately 36 million tonnes of CO_2 equivalent by 2030. Compared to the trend scenario, the implementation of the transformation scenario can further reduce the emission level by 38 million tonnes of CO_2 equivalent by 2030.

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Appendix

Tab. 1: Characteristics of the descriptors for sectoral futures

<table>
<tr><th>Sectoral Future I</th><th>Sectoral Future II</th><th>Sectoral Future III</th><th>Sectoral Future IV</th></tr>
<tr><td colspan="3">Fuel prices:
Strong increase</td><td>Fuel prices:
Minor increase</td></tr>
<tr><td>Disposable income:
Decreasing</td><td>Disposable income:
Constant</td><td>Disposable income:
Decreasing</td><td>Disposable income:
Constant</td></tr>
<tr><td colspan="3">Growth of GDP (national level):
Strong increase</td><td>Growth of GDP (national level):
Minor increase</td></tr>
<tr><td colspan="4">Demographic Change
Strong decrease</td></tr>
<tr><td colspan="3">Use of dez. energy supply options:
Strongly increasing</td><td>Use of dez. energy supply options:
Increasing</td></tr>
<tr><td colspan="3">Change of energy efficiency:
Strongly increasing</td><td>Change of energy efficiency:
Slightly increasing</td></tr>
<tr><td colspan="3">Working Population (No. of Persons):
Decreasing</td><td>Working Population (No. of Persons):
Constant</td></tr>
<tr><td>Relevance of households with elderly persons:
Increasing</td><td colspan="3">Relevance of households with elderly persons:
Constant</td></tr>
<tr><td colspan="4">Unit size (energy production units)
Increased application of small units</td></tr>
<tr><td colspan="3">Regional level of diversification:
Increasing</td><td>Regional level of diversification:
Constant</td></tr>
<tr><td colspan="3">Climate/energy policy on sectoral level:
Focus on reducing greenhouse gases</td><td>Climate/energy policy on sectoral level:
Focus on economics (less ambitious)</td></tr>
<tr><td colspan="3">Innovation dynamics:
Increasing</td><td>Innovation dynamics:
Constant</td></tr>
<tr><td colspan="3">Energetic quality of buildings:
High</td><td>Energetic quality of buildings:
Medium</td></tr>
<tr><td colspan="3">Rental charge/price of buildings and flats:
Increasing</td><td>Rental charge/price of building and flats:
Constant</td></tr>
</table>

Source: IEK-STE 2013

Tab. 2: Analysed measures in the scenarios

Trend-Scenario	Transformation-Scenario
Energy-efficient Refurbishment	Implementation of the Energy Saving Ordinance
Energy-efficient Construction	Tax breaks for renovations
Programme Urban Restructuring East	Renovation of rented apartment
Programme Urban Restructuring West	Increase market incentive program
Programme Active City and District Centres	Increase of KfW-efficiency standards
Promotion of Social Housing	Amendment of the Energy Saving Ordinance 2009
Market Incentive Programme (RES)	Increased use of District heating
Energy Saving Ordinance 2009	Stronger contribution of RES to Heat Supply (Bonus promotion)
Renewables Energies Heating Act	EU Ecodesign Directive
Heating Costs Ordinance	Application of the Renewable Energies Act to old buildings
	Additional reguirements of the Energy Saving Ordinance
	Heat Contracting in rented apartments
	Energy Efficient Renovation of Cities
	Additional Promoting: Urban Development Measures
	Additional Promoting: Demolition and construction of a building
	Change of Home Ownership Programme

Source: IEK-STE 20130 IEK-STE 2013

Tab. 3: Direct emission reductions in the trend scenario

Measure	Type	With effect from	Direct Emission Reductions 2015	2020	2025	2030
			in Mt CO2 eq.			
Energy-efficient Refurbishment	support programme	2001	4,4	7,9	11,5	15,1
Energy-efficient Construction	support programme	2005	0,1	0,2	0,2	0,2
Energy-efficient Refurbishment and Construction	*support programme*		*4,5*	*8,1*	*11,7*	*15,2*
Market Incentive Programme - Biomass	support programme	1996	2,3	4,1	5,9	7,7
Market Incentive Programme - Solar	support programme	1996	0,8	1,3	1,9	2,4
Market Incentive Programme - Heat pump	support programme	2008	0,3	0,6	0,8	1,0
Market Incentive Programme - Heat grid	support programme	2008	0,7	1,2	1,7	2,2
Market Incentive Programme	*support programme*		*4,1*	*7,2*	*10,3*	*13,4*
Programme Urban Restructuring East	support programme	2002	0,1	0,1	0,1	0,2
Programme Urban Restructuring West	support programme	2004	0,1	0,1	0,1	0,2
Programme Active City and District Centres	support programme	2008	0,0	0,1	0,1	0,1
Promotion of Social Housing	support programme	2001	0,0	0,1	0,1	0,1
Energy Saving Ordinance 2009	regulatory law	2009	1,2	2,3	3,4	4,5
Renewables Energies Heating Act	regulatory law	2009	0,2	0,3	0,4	0,5
Energieberatung vor Ort	support programme	2006	0,2	0,4	0,5	0,6
Heating Costs Ordinance	regulatory law	2009	0,1	0,2	0,3	0,4
Effects of measures			**10,5**	**18,8**	**27,0**	**35,1**
Effects of measures (without overlapping)			**9,1**	**16,2**	**23,2**	**30,2**

Source: IEK-STE 2013

Tab. 4: Direct emission reductions in the transformation scenario

Measure	Type	With effect from	Direct Emission Reductions 2015	2020	2025	2030
			in Mt CO2 eq.			
Implementation of the Energy Saving Ordinance	regulatory law	2013	1,0	4,4	10,3	16,3
Tax breaks for renovations	support programme	2013	0,4	1,7	4,0	6,3
Renovation of rented apartment	support programme	2013	0,9	2,8	4,5	6,2
Increase market incentive program	support programme	2013	1,0	2,3	3,6	4,9
Increase of KfW-efficiency standards	support programme	2013	0,7	1,5	3,2	4,8
Amendment of the Energy Saving Ordinance 2009	regulatory law	2013	0,5	1,5	3,1	4,7
Increased use of District heating	regulatory law	2013	1,0	2,2	3,4	4,7
Stronger contribution of RES to Heat Supply (Bonus promotion)	support programme	2013	0,9	2,1	3,3	4,4
EU Ecodesign Directive	regulatory law	2013	0,2	1,3	2,4	3,3
Application of the Renewable Energies Act to old buildings	regulatory law	2013	0,4	1,3	2,3	2,9
Additional reguirements of the Energy Saving Ordinance	regulatory law	2013	0,5	1,5	1,8	2,5
Heat Contracting in rented apartments	support programme	2013	0,2	0,7	1,2	1,7
Energy Efficient Renovation of Cities	support programme	2013	0,3	0,8	1,2	1,6
Additional Promoting: Urban Development Measures	support programme	2013	0,1	0,2	0,3	0,5
Additional Promoting: Demolition and construction of a building	support programme	2013	0,0	0,1	0,2	0,3
Change of Home Ownership Programme	support programme	2013	0,1	0,2	0,2	0,2
Effects of measures			**8,3**	**24,8**	**45,1**	**65,3**
Effects of measures (without overlapping)			**5,2**	**14,4**	**26,0**	**38,2**

Source: IEK-STE 2013

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